

Articulation Errors In Childhood Apraxia of Speech (CAS)

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Abstract

The purpose of this study was to characterize the articulation errors made by children with Childhood Apraxia of Speech (CAS) by type of error (omission, distortion, substitution or insertion) and by position of the error within the syllable (onset or coda). Errors made by children with CAS were compared against errors made by peers with other disorders (non-apraxic speech sound disorder and speech/language disorder). Since the presentation of CAS is known to be dynamic, the data was analyzed separately for children of preschool-age (4.00-6.25 years) and children of school-age (6.25-11 years). Results suggested that preschool-aged children with CAS make more *substitution errors at onset position* than comparison groups while school-aged children with CAS make more *omission errors at coda position* than comparison groups. Potential theoretical and clinical relevance of these results is discussed. In a separate analysis, a subset of children with CAS was followed longitudinally. From preschool-age to school-age, a significant increase in percentage of consonants correct was observed and a significant decrease in substitution errors was observed. Coda omission errors, however, did not significantly decrease. The persistence of coda omissions into school-age may be a hallmark of CAS.

Research Questions & Hypotheses

Research Question 1

Do the rates of various types of articulation errors (omissions, distortions, substitutions, and insertions) differ among children with suspected CAS, children with isolated, non-apraxic speech sound disorder (SSD), and children with speech and language disorder (SL)?

Hypothesis 1

There will be between-group differences in the mean rates of each error type.

Research Question 2

Do the rates of various articulation errors made by preschool-aged children with CAS differ from the rates observed for the same children at school-age?

Hypothesis 2

The rates of various errors made by children with CAS at preschool-age will change significantly by school-age.

Methods

Participants

Seventy-five speech samples of preschool-aged and school-aged children were analyzed. Preschool-aged samples were produced by 32 males and 5 females; school-aged samples were produced by 29 males and 9 females. This male:female ratio reflects the current prevalence estimates reported in the literature. Diagnostic groups included CAS (12 preschool-aged and 13 school-aged children with suspected CAS), SSD (14 preschool-aged and 16 school-aged children with non-apraxic speech sound disorder) and SL (11 preschool-aged and 9 school-aged children with speech and language disorder). Group inclusion criteria were based on clinical diagnoses and other evidence-based characteristics.

Measures

The Sounds-In-Words subtest of the Goldman-Fristoe Test of Articulation was administered to subjects and recordings were obtained for the purposes of this analysis. Eleven of the C-V-C words in the subtest were targeted for analysis. Articulation errors were categorized as distortions, substitutions, insertions, or omissions. Position of error (syllable onset or coda) was also noted. The Percentage of Consonants Correct (PCC) (Shriberg & Kwiatowski, 1982) was also calculated to obtain an overall picture of articulatory accuracy.

Analyses

Mean rates of errors were compared among the three diagnostic groups (CAS, SSD, and SL) using 1-way ANOVAs. When significant, ANOVAs were followed by post-hoc Tukey tests. For the children in the longitudinal portion of the study, mean rates of errors were compared with paired t-tests. ANOVAs were confirmed non-parametrically with Kruskal-Wallis tests and paired t-tests were confirmed with Wilcoxon matched-pairs signed-ranks tests. Parametric tests were confirmed non-parametrically as needed. The diagnostic utility of various error types for the identification of children with CAS was evaluated using the C-statistic from Receiver Operating Characteristic (ROC) curve analyses.

Results

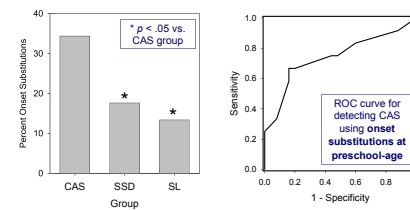
Preschool-aged Children

Mean rates of *substitution errors at onset position* significantly differed between the three diagnostic groups ($p=0.008$). Post-hoc tests showed that the difference was driven by the high rate of onset substitution in the CAS group. ROC curve analyses showed the significance of this error type/position in the detection of CAS at preschool-age (area under the curve=0.742, $p=0.019$).

Error Type Means (%) for Preschool-Aged Children

Error Types	CAS		SSD		SL		ANOVA P
	Mean	SD	Mean	SD	Mean	SD	
Onset Errors							
Distortion	6.89	7.90	7.35	6.45	6.78	6.25	.975
Substitution	34.39	22.81	17.61	12.58	13.39	10.87	.008**
Insertion	0.00	0.00	0.00	0.00	1.74	3.87	.085
Omission	1.52	3.54	0.65	2.43	0.00	0.00	.358
Coda Errors							
Distortion	6.89	7.90	9.16	11.28	5.95	7.45	.689
Substitution	24.39	18.14	13.44	11.86	13.47	11.10	.092
Insertion	4.02	6.55	4.68	6.03	4.38	5.04	.961
Omission	15.91	27.17	3.39	4.75	6.69	5.92	.144

* $p < .05$ ** $p < .01$



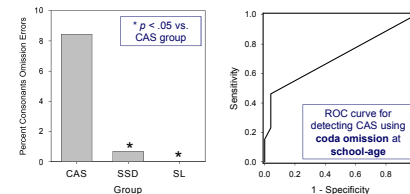
School-aged Children

Mean rates of *omission errors at coda position* significantly differed between the three diagnostic groups ($p=0.022$). Post-hoc tests showed that the difference was driven by the high rate of coda omission in the CAS group. ROC curve analyses showed the significance of this error type/position in the detection of CAS at school-age (area under the curve= 0.709, $p=0.036$).

Error Type Means (%) for School-Aged Children

Error Types	CAS		SSD		SL		ANOVA P
	Mean	SD	Mean	SD	Mean	SD	
Onset Errors							
Distortion	7.27	8.33	2.40	4.32	2.02	4.01	.061
Substitution	6.89	11.53	1.96	5.86	0.00	0.00	.102
Insertion	0.00	0.00	0.00	0.00	0.00	0.00	1.000
Omission	0.77	2.77	0.00	0.00	0.00	0.00	.393
Coda Errors							
Distortion	7.71	11.49	5.54	9.42	1.01	3.03	.256
Substitution	5.66	8.77	1.25	5.00	4.04	6.60	.230
Insertion	3.21	5.09	1.26	3.47	2.02	4.01	.469
Omission	3.44	13.40	0.69	2.78	0.00	0.00	.022**

* $p < .05$ ** $p < .01$



Children with CAS observed over time

Paired t-tests were used to compare errors made by a subset of children with CAS at preschool-age against the errors they made at school-age. Over time, articulation improved within the CAS group. This improvement was driven by significant decreases in the mean rates of errors of substitution at onset position ($p=0.011$) and coda position ($p=0.007$). The mean rate of coda omission errors decreased, but not by a significant degree ($p=0.203$). Errors of omission at coda position persisted into school-age.

Error Type Means (%) for Children with CAS at Two Ages

Error Types	Preschool		School Aged		P
	Mean	SD	Mean	SD	
Onset Errors					
Distortion	8.18	8.46	6.71	7.13	.728
Substitution	33.43	21.17	6.16	12.06	.011*
Insertion	0.00	0.00	0.00	0.00	1.000
Omission	1.01	3.03	1.11	3.33	.951
Coda Errors					
Distortion	7.17	7.61	5.58	10.16	.715
Substitution	30.71	16.58	6.16	6.49	.003**
Insertion	4.24	7.10	1.23	3.70	.241
Omission	18.18	31.16	8.41	14.73	.203

* $p < .05$ ** $p < .01$

Conclusions & Discussion

Research Question 1

The first hypothesis tested was that the rates of various types (omission, distortion, substitution or insertion) and positions (onset, coda) of articulation errors would differ among children with different speech and language diagnoses (CAS, SSD, and SL). This hypothesis was tested for preschool-age and school-age recordings in two different analyses.

At preschool-age, a between-groups difference in mean error rate was found only for the *substitution error type at onset position*. This difference was owed to the high rate of onset substitution errors made by children with CAS. The relative difficulty of onset consonant articulation at preschool-age might reflect the motor planning/programming deficits that define CAS, especially a difficulty initiating a motor sequence and transitioning from onset consonant to vowel.

At school-age, a between-groups difference in mean error rate was found only for the *omission error type at coda position*. Errors of omission at coda position change the C-V-C structure of the intended word to a C-V structure. This might, then, reflect partial contribution of a linguistic impairment at the level of syllable representation on top of the motor impairments that are known to characterize CAS.

Research Question 2

The second hypothesis tested was that the rates of various errors observed at preschool-age in the CAS group will change significantly by the time the speakers are of school-age. Longitudinal analyses showed that onset and coda substitution errors decline but coda omission errors persist. Coda omission was diagnostic of CAS at school-age. Thus, continued omission of coda consonants up to school-age might be a hallmark of the school-aged presentation of CAS and could be the most effective target for preschool-age and school-age intervention.

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